Mariner Venus/Mercury 1973 Mission Support

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This report covers the period from March 1, 1974, through April 15, 1974. April 15, 1974, marked the end of the Mariner Venus/Mercury 1973 (MVM'73) Project's primary mission and the beginning of the Mariner 10 Extended Mission Project. Consequently, this is the final report in the MVM'73 series; however, future reports will continue to summarize DSN support for the extended mission. March 1974 proved to be the most dynamic and critical period of this rather eventful mission. DSN preparations for trajectory correction maneuver (TCM) 3 and for Mercury encounter were completed, and support was provided in a near-flawless manner. In addition, this period saw the correction of some spacecraft problems and the occurrence of new problems requiring the DSN to respond rapidly with appropriate changes in plans, procedures, configurations, and schedules.

I. Planning Activities

During early March 1974, the DSN gave priority to preparations for TCM 3 and to development of the final sequence of events for Mercury encounter. TCM 3 was planned to occur over Deep Space Station (DSS) 14 on March 16, and the encounter TV sequence was planned around a 22.5-kbps data rate, rather than 117.6 kbps, because of the spacecraft antenna feed problem. However, two significant events during the first week of March 1974 required significant changes to these near-final arrangements.

On March 4, 1974, the spacecraft antenna problem corrected itself, thus reopening the possibility of real-time (117.6-kbps) TV operations at Mercury encounter. Further, on March 6, 1974, the spacecraft lost lock on Canopus, and gyros came on to provide attitude stability. However, the roll gyro began oscillating, which resulted in high consumption of attitude control gas. Gas usage effects on the orbit were such as to shift TCM 3 from the DSS 14 to the DSS 43 view period. Further orbit refinements again shifted the TCM to occur over DSS 63.

These problems and changes resulted in a heavy, unanticipated replanning load at a time when plans should have been in the final stage for the approaching encounter with Mercury. Revival of the 117-kbps TV sequence required development of special telecommunications link performance measurement tests, changes to planned DSS configurations, and schedule negotiations to accommodate MVM'73 and Pioneer during encounter. Orbit uncertainties due to nongravitational forces necessitated development and execution of special procedures for generation of simultaneous doppler data and near-simultaneous ranging data to accurately redefine the orbit following TCM 3. Furthermore, to preclude excessive gas consumption during any future loss-of-Canopus event, the spacecraft was placed into a "free-drift" mode using solar pressure on solar panels as an assist to attitude stabilization. In this mode, automatic gyro turn-on was inhibited. Consequently, loss of Canopus would result in the spacecraft's high-gain antenna drifting off the earth line, and 64-m DSS support would be needed for reacquisition. Therefore, special agreements were negotiated with the Pioneer Project, and new DSN procedures were developed wherein one telemetry string at the 64-m stations would always be configured for immediate MVM'73 support.

The introduction of these late but necessary changes shortly before the critical encounter period caused a great deal of DSN concern regarding the Network's ability to avoid operational errors which would be detrimental to the primary mission objectives. DSN Operations planners and advisors provided close support during this high-risk situation to help assure that required results were achieved.

II. Program Control

Weekly status meetings continued throughout this reporting period. Open implementation tasks and problem areas were tracked until appropriate closures were accomplished. Reports included weekly status messages via teletype and monthly inputs to the Project Management Report.

On March 7, 1974, the DSN conducted a special review of various discrepancy areas in the Network, particularly those which represented continuing problems and those which had a potential to impact Mercury encounter support. The Discrepancy Report (DR) Review Board consisted of representatives from DSN Operations and Engineering. Following is a summary of the significant items discussed.

A. Planetary Ranging

The recently implemented planetary ranging capability soon logged a number of discrepancies. Many of these problems were traceable to a lack of operational experience, which significantly improved with time. However, error dispersions continued to be larger than anticipated, and frequent biases and offsets were observed between and within station passes. DSS 63 exhibited a rather consistent 20-m bias. The consensus was that this ranging performance would meet MVM'73 navigation requirements and that ranging assemblies should not be perturbed by any rework prior to end of the mission. Recommended areas for on-going study included: (1) recalculate and verify the 64-m antenna Z-height, (2) check for timing errors as a possible cause, (3) resurvey the DSS 63 site location, and (4) evaluate calibration accuracies using the zero-delay device, and as a function of antenna angle position.

B. DSS Command Subcarrier-Frequency and Bit-Rate Error Alarms

Alarms of this nature occur periodically and account for a large percentage of open DRs in the system; 30 were open at the time of the review. It is important to note that these are alarms, not aborts. The DSN has experienced only one command abort for MVM'73, which was due to an erroneous bit rate. Standard practice is to set the subcarrier-frequency alarm limit tighter than the Project abort limit; e.g., alarm at ±0.2 Hz, abort at ±0.3 Hz deviation. Analysis of DSS analog tape readouts disclosed that 80% of the bit-rate error alarms were false alarms resulting from bit-rate detection circuitry errors rather than actual bit-rate errors.

Two approved engineering change orders which would correct a clock–counter interface problem were available for implementation. However, it was decided that installation would be delayed until after Mercury encounter. Also, a widening of the subcarrier frequency tolerance can be accommodated easily during prepass initialization, but the Project requested that the present alarm limits be maintained.

When these alarms occur, they usually clear immediately, and normal commanding is continued. Infrequently, alarms persist, requiring switch to the backup command string. In either case, short delays have had little or no effect on mission operations, since Mariner 10 is an automated spacecraft. However, concern increases with the number of spacecraft emergencies requiring critical ground command activity.

C. Data Decoder Assembly

Although installation of new selector channels and other modifications significantly improved data decoder assembly (DDA) performance, problems continued throughout the Network. A number of discrepancies were grouped into two categories: DDA external and DDA internal.

(1) DDA external: This category includes those events involving DDA halts and alarms. These problems are intermittent and are usually cleared in less than 10 min by DDA reinitialization or reload. Cause analysis has been difficult because of a lack of data. Deep Space Stations need to dump the DDA memory when a halt/alarm occurs in order to get useful trouble-shooting data; however, most projects are reluctant to approve an additional 15–20 min data outage while this is done. Post-review coordination with the MVM'73 Project resulted in an agreement and procedure for DDA memory dumps as required when critical data were not being handled.

(2) DDA internal: This category includes those discrepancies involving bit errors, improper data sequences, and timing errors. Telemetry data timing errors are now being worked around by special operational procedures involving front panel restarts when errors are observed. Of more concern is the mixing of data in the DDA through a linear combination of bits. This was observed on some of the Venus encounter digital original data records. All bits were recorded but were out of sequence in a systematic interleaving pattern. It was suggested that this was an initialization procedure problem. Actions were assigned for special testing to verify the specific cause and obtain a solution. Results of these tests are discussed in Section III-A2.

The DSN Operations Status Review for Mercury encounter was conducted on March 21, 1974. The purpose was to evaluate the final status of encounter preparations and review potential problem areas. Subjects covered included: test and training, documentation updates, encounter time lines, occultation strategy, configurations, configuration freeze plans, data shipment plans, staffing, and discrepancy report status. All items exhibited a satisfactory readiness posture for the start of encounter operations.

III. Implementation Activities

A. Deep Space Stations

Previous Progress Reports have tracked DSS subsystem implementation progress for MVM'73. All major work was completed prior to Venus encounter in February 1974; consequently, this section continues to diminish, reflecting only tasks to resolve problem areas.

1. Antenna microwave subsystem. An earlier article reported on DSN initiation of emergency implementation of linear polarization tracking capabilities in the 64-m subnet to match the changed polarization in the spacecraft due to high-gain antenna problems. Although this spacecraft problem corrected itself on March 4, 1974, implementation of linear polarization was continued as a contingency against future recurrences. This task, including performance verification tracking tests, was completed by mid-March 1974 as planned.

2. Telemetry and command data subsystem. Return of the spacecraft telecommunications link to normal gain and polarity again made real-time 117.6-kbps TV data possible at Mercury encounter. Consequently, the previously reported problem in digital original data records of 117-kbps data was given priority attention. Special tests were conducted at DSS 14 and Compatibility Test Area (CTA) 21 to determine the cause of recorded data being out of sequence. As suspected, the problem was operationally induced and could be corrected by changes in operational procedures. To avoid having pre-pass countdown simulated data on the record delivered to Project, the original procedure called for loading of virgin tapes following countdown activities. This apparently left the DDA pointers out of phase with the high-density recorder tape position. The high-density cycle at 117 kbps resulted in a linear combination of bits in about 25% of the test cases. Reinitialization of the DDA following loading of new tapes was required to avoid this problem. Special operational instructions to this effect were issued to the DSS. No further indications of the problem were observed in the Mercury encounter data.

3. S/X-band equipment. The special team effort for improvement of the R&D S/X-band performance at DSS 14 was continued throughout this reporting period. Receiver control work, cable replacements, and other trouble-shooting analysis produced an acceptable level of data quality for encounter operations. Previously reported problems with the command modulator assembly switch were not completely resolved prior to Mercury encounter. Therefore, operations were continued in the Block III

exciter rather than the desired Block IV exciter mode. This configuration was acceptable to the MVM'73 Project.

B. DSN Ground Communications

There was no significant DSN communications implementation during this period. However, per NASA request, the DSN did coordinate the planning, configuration, test, and schedules for establishing a video circuit capability from JPL to Goddard Space Flight Center and NASA Headquarters. This service was employed for about 7 h during Mercury encounter to transmit real-time encounter TV and public information broadcasts to these NASA viewers.

IV. Operations Summary

As planned, increasing use was made of the 64-m subnet during March–April 1974 for the trajectory correction maneuver and encounter support. However, Pioneer Project tracking requirements limited the configuration freeze for MVM'73 to an 8-day period around encounter. Standard DSN encounter readiness tests were completed by mid-March 1974. However, special telecommunications link performance and S/X-band performance tests were continued until encounter day. DSN support continued to be satisfactory, with excellent performance demonstrated during the critical encounter sequence and during the occurrence of some additional spacecraft problems.

On March 31 (GMT), at the start of an outgoing TV mosiac sequence, a spacecraft power subsystem problem occurred which resulted in large power dissipations in the spacecraft bus. One of the resulting effects was intermittent reduction of the X-band transponder output power by 27 dB and the development of sidebands on the carrier. A special effort was made at DSS 14 to detect sidebands and analyze their character.

April 15, 1974, marked the end of the successful MVM'73 primary mission. An extended mission for a return to Mercury has been approved. Work on DSN plans for continuing support has been initiated. Future articles will address the Mariner 10 Extended Mission Project.